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THE FOYAITE-IJOLITE SERIES OF MAGNET COVE: A CHEMICAL STUDY IN DIFFERENTIATION.

INTRODUCTORY.

SOMETIME since I published a paper[1] on the "Igneous Complex of Magnet Cove," in which it was shown that the main types found there were arranged in a very regular series from the center to the periphery of the mass, and that this was an excellent example of the differentiation of a magma in place, presenting, however, the anomaly of being less "basic" at the borders than at the center. It was also remarked that the analyses then available "vary continuously in one direction, with scarcely a break or abnormality of any kind."[2]

Since then several considerations led to the belief that a new and more detailed chemical examination of the main rock types was desirable. Several of these, notably the "leucite-porphyry" and ijolite, are representatives of rock groups of great theoretical importance, complete analyses of which are highly desirable. In this respect many of those published by Williams[3] are defective, the non-determinations of the rarer constituents being largely due to the fact that the importance of completeness in rock analysis was not recognized at the time they were made.[4]

Such a reëxamination seemed to be the more desirable, since in a recent paper Pirsson[5] has shown that the rocks occurring in the Little Belt Mountains of Montana form an extremely regular series. By plotting the constituent oxides on an abscissal basis of distance from the center of the mass, he arrived at the conclusion in this case that, "given the percentage of one element, the chemical composition of any rock of the series to within a fraction of 1 per cent. can be deduced from the diagram." This instance is the first in which the differentiation of a mass of magma is rendered capable of exact mathematical treatment and proof, and its great theoretical interest and importance is obvious. The conditions of the locality were such that it was thought that the Magnet Cove complex might furnish another favorable example of the same kind, a hope which was justified by the results obtained, as will be seen later.

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[1] *Bull. Geol. Soc. Amer.*, Vol. XI, p. 389, 1900.

[2] *Op. cit.*, p. 403.

[3] J. F. WILLIAMS, "Igneous Rocks of Arkansas." *Ann. Rep. Geol. Surv. Ark.* Vol. II, 1890.

[4] *Cf.* J. C. BRANNER, in Williams, *op. cit.*, p. xiv.

[5] L. V. PIRSSON, *Twentieth Ann. Rep. U. S. Geol. Surv.*, Part II, p. 569 ff., 1900.

The analyses of six of the representative plutonic rocks of Magnet Cove, as well as two of Fourche Mountain, were therefore undertaken, with the determination of the rarer constituents which might be present. For petrographic descriptions the reader is referred to the two papers cited above.

In this connection I would express my full endorsement of Pirsson's remarks[1] on the importance of good and complete analyses, which are absolutely essential for such mathematical discussion, and with him deplore their comparative rarity. To many petrographers, any collection of figures which foots up within 98 and 102 per cent. is a usable analysis, even though the results are at variance with the mineralogical composition, and some of the obviously important constituents are not estimated. It is not realized that such "analyses" do far more harm than good to the science. From this point of view alone, the excellent work of Dr. Hillebrand and the other chemists of the United States Geological Survey is of inestimable value, as they have set a standard to fall short of which in any marked degree should be accounted a petrographic sin. Let me be the first to confess "*peccavi.*"

ANALYSES.

Pulaskite.—The specimen of this type was collected at the Little Rock Granite Company's quarry, at Fourche Mountain, near Little Rock, the type locality. In I is given my analysis, in II that of R. N. Brackett, as quoted by Williams. The two do not differ materially, I showing rather less Fe_2O_3 and CaO and more FeO, MgO, and alkalis, though the ratio of

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[1] L. V. PIRSSON, *op. cit.*, p. 578.

	I	II		I	II
SiO_2	60.20	60.03	TiO_2	0.14	....
Al_2O_3	20.40	20.76	ZrO_2	trace	....
Fe_2O_3	1.74	4.01	P_2O_5	0.15	0.07
FeO	1.88	0.75	SO_3	0.13	....
MgO	1.04	0.80	Cl	0.09	....
CaO	2.00	2.62	S	none	....
Na_2O	6.30	5.96	MnO	trace	trace
K_2O	6.07	5.48	BaO	trace	....
H_2O(110°+)	0.23	0.53			
H_2O(110°—)	0.10	0.06		100.47	101.07
C_2O	none	....			

I. Pulaskite, Fourche Mountain. Washington, analyst.

II. Pulaskite, Fourche Mountain. Brackett, analyst. WILLIAMS, *op. cit.*, p. 70.

$Na_2O : K_2O$ is about the same in both, being 1.57 in I and 1.66 in II. The specimen analyzed by Brackett apparently contained a little more acmite, though the variations are scarcely more than are to be expected in different specimens from the same mass.

Analysis I can be calculated out as below. There is apparently an excess of Al_2O_3, amounting to about 4 per cent. in this, as well as in II, which it is difficult to account for. It does not seem to be due to kaolinite or hydronephelite, as the rock is too fresh, and there is no muscovite present. Such an excess of Al_2O_3 above $(Na_2O+K_2O) - Fe_2O_3$ may be observed in many analyses of nephelite-syenites, if the Fe_2O_3 is calculated as acmite, and no anorthite molecule is assumed to be present. Among these are some by Hillebrand, and there is no reason to suppose that this peculiarity is due to errors of analysis. It is a feature of this group of rocks which seems to call for investigation, and may possibly be connected with the occurrence of corundum in the nephelite-syenites.

Orthoclase	35.1
Albite	39.8
Nephelite	3.1
Sodalite	1.2
Aegirite	5.1
Hornblende, diopside, and biotite	11.0
Apatite	0.5
Extra alumina	4.2
	100.0

Pulaskite (*Foyaite*).—This is Williams's "gray granite," the specimen coming from Braddock's quarry, on Fourche Mountain. My analysis is given in I below, with that of W. A. Noyes as quoted by Williams in II. The two are closely alike in all

	I	II		I	II
SiO_2	60.13	59.70	CO_2	none	....
Al_2O_3	20.03	18.85	TiO_2	1.15	....
Fe_2O_3	2.36	4.85	ZrO_2	0.05	....
FeO	1.33	....	P_2O_5	0.06	....
MgO	0.76	0.68	SO_3	0.14	....
CaO	0.87	1.34	MnO	trace	....
Na_2O	6.30	6.29	BaO	trace	....
K_2O	5.97	5.97			
H_2O(110°+)	1.41	1.88		100.72	99.56
H_2O(110°−)	0.16	....			

I. Pulaskite, Braddock's quarry, Fourche Mountain. Washington, analyst.
II. Pulaskite ("Foyaite"), same locality. Noyes, analyst. WILLIAMS, *op. cit.*, p. 81.

respects except Al_2O_3, which is about 2 per cent. higher in I, as about 1 per cent. of TiO_2, and a trace of P_2O_5 must be deducted from the Al_2O_3 of II.

The analysis (1) calculates out as follows, and it is evident that there is no essential difference between this rock and the last mentioned.

Orthoclase -	28.6
Albite - - -	39.0
Nephelite - -	6.2
Nosean - -	1.2
Kaolin - -	7.5
Aegirite - -	6.9
Biotite - -	7.9
Titanite - -	2.7
	100.0

Foyaite.—What seemed to be an average specimen of the occurrence at Diamond Jo quarry, Magnet Cove, was chosen for analysis. No pyrite was visible, though the analysis shows a trace of sulphur. One or two small garnets were seen in one section, which mineral is not mentioned by Williams as an accessory.

Apart from the determination of minor constituents, my analysis (1) does not differ materially from that of Brackett and Smith (II), except in the presence in the latter of nearly 2 per cent. of pyrite, and in the alkalis. I gives a ratio of $Na_2O : K_2O$ of 1.3, while in II it is 1.92. The amount of BaO in I is high, and is noteworthy since it is found only in traces or not at all in the other rocks. It probably belongs with the abundant orthoclase, since other cases are known of BaO partially replacing K_2O in the feldspar of alkaline rocks. The analysis calculates out thus:

	I	II	I	II	
SiO_2	53.09	53.38	TiO_2	0.11	....
Al_2O_3	21.16	20.22	ZrO_2	0.04	....
Fe_2O_3	1.89	1.56	P_2O_5	0.15	....
FeO	2.04	1.99	SO_3	none	....
MgO	0.32	0.29	Cl	0.02	....
CaO	3.30	3.29	S	0.08	1.77[1]
Na_2O	6.86	7.89	MnO	0.20	trace
K_2O	8.42	6.21	BaO	0.61	....
$H_2O(110°+)$	1.13	3.43			
$H_2O(110°-)$	0.24			100.48	100.03
CO_2	0.82				

I. Foyaite, Diamond Jo quarry, Magnet Cove. Washington, analyst.

II. Foyaite, same locality. Brackett and Smith, analysts. WILLIAMS, Sp. gr. 2.599 at 26°C., *op. cit.*, p. 238.

Orthoclase -	51.8
Nephelite - -	20.3
Cancrinite -	13.1
Aegirite - -	5.7
Diopside - -	8.6
Titanite and pyrite -	0.5
	100.0

It is seen that this bears out Williams's remark that "the orthoclase is perfectly free from isomorphous mixtures of other feldspars." It is indeed somewhat remarkable that the albite molecule should be entirely lacking, or almost so, in a rock containing so much soda. It seems to be characteristic of the

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[1] FeS_2.

Magnet Cove rocks that albite, as well as anorthite and hornblende, are of very limited occurrence.

Covite (*"Shonkinite"*).—The specimen of this rock, which is Williams's "fine grained syenite," came from below the schoolhouse on the western border of the Cove, and the analysis was published in my former paper. It is repeated here, with the addition of P_2O_5, which has been determined since. Several analyses of analogous rocks are also given.

	I	II	III	IV	V
SiO_2	49.70	44.65	47.61	48.98	46.99
Al_2O_3	18.45	13.87	14.26	12.29	17.94
Fe_2O_3	3.39	6.06	4.90	2.88	2.56
FeO	4.32	2.94	4.07	5.77	7.56
MgO	2.32	5.15	2.62	9.19	3.22
CaO	7.91	9.57	8.71	9.65	7.85
Na_2O	5.33	5.67	6.70	2.22	6.35
K_2O	4.95	4.49	4.08	4.96	2.62
H_2O(110°+)	1.09	2.10	1.89	0.56	0.65
H_2O(110°−)	0.25	0.95	0.26	0.26	....
CO_2	....	0.11	....	....	....
TiO_2	1.33	0.95	1.38	0.98	0.94
ZrO_2	....	....	0.18	....	....
P_2O_5	0.40	1.50	1.38	0.98	0.94
SO_3	....	0.61	....	....	....
Cl	....	trace	0.37	....	....
F	....	....	trace	0.22	....
S	....	....	0.03	....	....
MnO	trace	0.17	0.30	0.08	trace
BaO	....	0.76	0.41	0.43	none
SrO	....	0.37	0.36	0.08	....
	99.44	99.99	100.68	99.99	99.60

I. Covite, Below Schoolhouse, Magnet Cove. Washington, analyst. *Bull. Geol. Soc. Amer.*, Vol. XI, p. 399, 1900.

II. Theralite, Gordon's Butte, Crazy Mountains, Montana. Hillebrand, analyst. J. E. WOLFF, *Bull. No. 150* U. S. Geol. Surv., p. 201, 1898.

III. "Tinguaite," Two Buttes, Colo. Hillebrand, analyst. *Bull. 148* U. S. Geol. Surv., p. 182, 1897.

IV. Shonkinite, Yogo Peak, Little Belt Mountains, Montana. Hillebrand, analyst. WEED and PIRSSON, *Am. Jour. Sci.*, Vol. L, p. 474, 1895.

V. Essexite, Salem Neck, Mass. Washington, analyst. JOUR. GEOL., Vol. VII, p. 57, 1899.

The mineralogical composition of these rocks is such that their calculation must, of necessity, be arbitrary and only approximate, but those of I, II, IV, and V may be very roughly reckoned out, as below, that of IVa being Pirsson's calculation.

	Ia	IIa	IVa	Va
Orthoclase	29.3	29	25	16.3
Albite	22.8	..		13.3
Anorthite	....	..	10	17.2
Nephelite	9.0	23	..	20.1
Haüyne	....	4	..	....
Aegirite	4.5	4	..	3.7
Diopside	9.0	25	35	3.7
Hornblende	18.8	..	5	7.2
Biotite	....	..	18	....
Olivine	....	2	7	9.2
Magnetite	2.5	7	..	4.3
Titanite	3.1	2	..	4.0
Apatite	1.0	4	..	1.0
	100.0	100	100	100.0

In my former paper I discussed briefly the position of this rock in classification, and provisionally put it with the shonkinites. At that time the mineralogical composition had not been calculated, and this position was assigned to it because it resembled Pirsson's shonkinites, except in the presence of nephelite and of hornblende instead of biotite, and also because it came under Rosenbusch's definition[1] of these rocks, whose essential features according to him, are the presence of abundant dark minerals along with nephelite and orthoclase. As was also remarked, it cannot be put with the essexites or theralites (although chemically closely resembling these), on account of the lack of plagioclase.

In this connection it is of great interest to note the fact that, in his latest description[2] of typical theralite, J. E. Wolff states that there is nothing which can strictly be called soda-lime feldspar present. Indeed this fact is evident from a consideration of the analyses by Hillebrand, published in the same place. The name theralite, therefore, cannot be applicable to Wolff's Montana rocks, or else its definition must be changed.

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[1] ROSENBUSCH, *Elemente der Gesteinslehre*, p. 174, 1898.

[2] *Bull. U. S. Geol. Surv.*, No. 150, p. 197, 1898.

It will be seen that, though the covite and the theralite of Wolff resemble each other in qualitative mineralogical composition, as both are composed essentially of alkali-feldspar, nephelite and ferromagnesian minerals, and that both are distinctly leucocratic in character, yet that in a quantitative mineralogical way they are decidedly different. The feldspathic constituents of the covite are very largely feldspar, with only accessory amounts of nephelite, while the theralite shows about as much feldspathoid as feldspar. The calculation of the latter cannot be exact, since some of the soda goes into the feldspar, but this must be small, and cannot affect the result to any great extent. It is evident, then, that the name of theralite is not appropriate for the Magnet Cove rock, though it might be used in the present very vague and loose method of classification, based largely on qualitative mineralogical composition.

A comparison of Pirsson's descriptions[1] with Rosenbusch's definition of shonkinite indicates that the latter has been apparently laboring under a misapprehension of the former's descriptions, and that his definition does not cover the rocks as Pirsson described them. Pirsson expressly states in each case that nephelite is either entirely absent or present only in mere traces, which does not coincide with the definition which makes nephelite an essential constituent.

Although resembling each other in many ways, yet there are certain striking differences between the analysis of the Magnet Cove rock and those of shonkinite. In SiO_2, iron oxides, CaO and K_2O they are closely alike, but in the Magnet Cove rock Al_2O_3 and Na_2O are higher and MgO lower. Indeed the calculations of the mineralogical composition, though that of Ia is only approximate, show clearly that while the "covite" is distinctly leucocratic the shonkinite is as decidedly melanocratic. A similar distinction will be pointed out between the "leucite-porphyry" and missourite. In this respect the rock under consideration resembles the typical essexite, though here again there is a distinct difference in the amount of K_2O, in the essexite this being much lower, and plagioclase entering to a very considerable extent.

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[1] L. V. PIRSSON, *Bull. Geol. Soc. Am.*, Vol. VI, p. 408, 1895; *Am. Jour. Sci.*, Vol. L, p. 474, 1895; *Am. Jour. Sci.*, Vol. I, p. 358, 1896.

For this leucocratic holocrystalline combination of orthoclase (alkali-feldspar) and less nephelite, with hornblende and aegirite-augite, of granitic structure, and with a composition like that given in the analysis above, I would propose the name of Covite. If only the qualitative, not the quantitative, mineralogical composition be considered, the covites may be called basic nephelite-syenites or foyaites. But the whole tendency of modern petrography is, rightly, against this narrow view of rock classification, and the use of a new name seems to be abundantly justified. In ordinary typical foyaites the alkali-feldspars and nephelite, etc., make up from 75 to 90 per cent. of the rock, the dark minerals consequently only from 10 to 25 per cent. In the covites, on the other hand, while the type is rather leucocratic, the light and dark minerals are present more nearly in the same amount, and these rocks might justly be called " mesocratic."

As a matter of fact, accepting Pirsson's definition of shonkinite as the standard (viz., melanocratic combination of alkali-feldspar with pyroxene, etc.), the covites are the rocks which correspond to Rosenbusch's definition of shonkinite. A similar rock, which also belongs here, is that the analysis of which is given in III, and which Cross provisionally called a " tinguaite."

Arkite ("*Leucite-porphyry*").—The specimen which was selected for analysis came from an exposure a little to the northeast of and above Diamond Jo quarry. Judging from the other specimens which I collected around the area, it seemed to be representative and an average specimen of the occurrences. A good sized hand specimen was used for the analysis, so as to obtain a fair sample of this rather coarsely porphyritic rock.

The results, given in I, were rather surprising in comparison with the analysis by W. A. Noyes of another specimen from the neighborhood (II). Not only is SiO_2 much lower, but MgO is a little higher, CaO much more so, and, though the total amount of alkalis remains the same, the new analysis shows a rock relatively richer in potash as compared with soda.

	I	II	III		I	II	III
SiO_2	44.40	50.96	46.06	ZrO_2	0.03	....	....
Al_2O_3	19.95	19.67	10.01	P_2O_5	0.37	....	0.21
Fe_2O_3	5.15	7.76	3.17	SO_3	0.06	trace	0.05
FeO	2.77	.....	5.61	Cl	trace	0.25	0.03
MgO	1.75	0.36	14.74	MnO	0.08	trace	trace
CaO	8.49	4.38	10.55	BaO	0.01	....	0.32
Na_2O	6.50	7.96	1.31	SrO	....	....	0.20
K_2O	8.14	6.77	5.14				
H_2O (110°+)	1.17	1.38	1.44		100.76	100.01	99.57
H_2O (110°−)	0.24	.....	.....	Less O = Cl	......	0.06	0.01
CO_2	0.12	.....	.....				
TiO_2	1.53	0.52	0.73		......	99.95	99.56

I. Arkite, Magnet Cove. Washington, analyst. Sp. gr., 2.770 at 26° C.
II. Arkite, Magnet Cove. Noyes, analyst. WILLIAMS, *op. cit.*, p. 276.
III. Missourite, head of Shonkin Creek, Highwood Mountains, Montana. Hurlbut, analyst. WEED and PIRSSON, *Am. Jour. Sci.*, Vol. II, p. 321, 1896.

The discrepancy between the two analyses of the leucite rock cannot be explained by the supposition that the specimen analyzed by Noyes carried a larger proportion of pseudo-leucite, since, although the other constituents work out well on this basis, the amount of K_2O in II is not intermediate between that in I and in Williams' analysis of a pseudo-leucite crystal. It seems to be the case that Noyes' specimen represents a slightly different phase, possibly richer in aegirite, but poorer in diopside and garnet. From my own observations in the field and the specimens collected, I conclude that the specimen of I represents the normal rock more closely than that of II.

It may be remarked that this supposition is borne out by the fact that analysis I is, in a general way, intermediate between that of the covite and that of the ijolite, given later, while Noyes' is not. This is to be expected in view of the observation noted in my former paper (p. 395), that "while the relations of the 'fine grained' (shonkinitic) syenite to the leucite-porphyry are uncertain, the former lies apparently outside or above the latter."

In the absence of discrimination between the two iron oxides in II, it is impossible to make a satisfactory calculation of Noyes' analysis, but No. I works out thus, the result being only an approximation, owing to the composition of the rock. In IIIa is given that of the missourite, as calculated by Pirsson.

	Ia		IIIa
Orthoclase	3.9	Leucite	16
Leucite	36.9	Analcite	4
Nephelite	25.5	Zeolites	4
Aegirite	8.4	Augite	50
Diopside	10.8	Olivine	15
Garnet	14.5	Biotite	6
		Iron ore	5
	100.0		100

It is evident from this table that while both rocks are alike in being composed essentially of leucite, with subordinate nephelite (or zeolites), and dark minerals, yet that they differ radically from each other, just as did the covite and shonkinite. The Magnet Cove rock is distinctly leucocratic, carrying about 66 per cent. of light minerals, while the missourite is as decidedly melanocratic, carrying only 24 per cent. of these.

It is obvious from the mineralogical composition, as well as from the analysis, that the name "syenite" which has been applied to this rock is not justified, if this term is to retain any precision of meaning except that of indicating the absence of quartz and an alkaline character. Since this is so, and since the rock represents a most interesting and quite distinct type, it certainly should have a distinct appellation of its own.

It would seem peculiarly appropriate to honor the memory of its first describer, J. F. Williams, by calling it Williamsite. But since this name has been already preëmpted by Shepard for a variety of serpentine, and as it would be a solitary exception among rock names, it will be best not to do so. I propose, therefore, the name of "arkite" (from the usual abbreviation of the state name Arkansas), the essential features being a holocrystalline, porphyritic, leucocratic combination of leucite (or pseudo-leucite) and nephelite, with pyroxene and garnet.

Ijolite.—The analysis of this type, from below Dr. Thornton's, has been already published,[1] but is here repeated, with the addition of several constituents which have been determined since. In II is given the analysis of a typical ijolite from Iiwaara, in Finland. The two do not differ materially, except that I is higher in CaO and correspondingly lower in Na_2O.

	I	II		I	II
SiO_2	41.75	43.70	CO_2........	none	....
Al_2O_3	17.04	19.77	TiO_2.......	0.58	0.89
Fe_2O_3	6.35	3.35	ZrO_2.......	0.05	....
FeO	3.41	3.94	P_2O_5	1.09	1.34
MgO........	4.71	3.94	S	none	....
CaO........	14.57	10.30	MnO	trace	trace
Na_2O.......	6.17	9.78	BaO	none	....
K_2O........	3.98	2.87			
H_2O(110°+)	0.62	0.89		100.60	100.30
H_2O(110°−)	0.28				

I. Ijolite, Magnet Cove. Washington, analyst. *Bull. Geol. Soc. Am.*, Vol. XI, p. 399, 1900. Sp. Gr. 3084—26°C.

II. Ijolite, Iiwaara, Finland. Sahlbom, analyst. V. HACKMAN, *Bull. Com. Geol. Finl.*, No. 11, p. 17, 1900.

The mineralogical composition of the two is given below, that of IIa being Hackman's calculation. II is almost exactly half nephelite, while I contains rather less than half of this mineral, but both may reasonably be called mesocratic. Hackman's specimen did not contain any garnet, but this is a very

	Ia	IIa[2]
Nephelite..........	38.7	55.00
Aegirite...........	4.6	7.15
Diopside..........	31.3	33.22
Augite	6.9	.....
Melanite..........	15.3	.....
Titanite...........	....	2.16
Apatite	3.0	3.17
	100.0	100.70

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[1] H. S. WASHINGTON, *op. cit.*, p. 399.

[2] There is a clerical error in Hackman's results, as he gives the nephelite as 51.02, the sum as 100.50.

variable constituent in the Finland ijolites. Hackman (*op. cit.*, p. 4) notes the identity between the Magnet Cove rock and the Finland and Alnö ijolites.

Biotite-ijolite.—An analysis was also made of this rock, the specimen coming from near the Baptist church, and the results are given in I. My specimen was, unfortunately far from fresh, so that the figures are of little value. Williams' analysis (II) of the same type, undoubtedly made on fresher material, is to be preferred. The chief feature of interest in I is the (for this oxide) large amount of ZrO_2, which may be correlated with the neighboring "eudialyte-syenite pegmatite" described by Williams.

	I	II		I	II
SiO_2	38.11	38.93	SO_3	none	....
Al_2O_3	20.84	15.41	Cl	....	0.02
Fe_2O_3	5.67	5.10	S	0.14	0.89[1]
FeO	1.46	4.24	MnO	0.14	trace
MgO	3.80	5.57	BaO	trace	....
CaO	14.44	16.49	SrO	....	trace
Na_2O	6.65	5.27	Li_2O.......	....	trace
K_2O	2.12	1.78			
H_2O(110°+)	4.51	5.20		100.60	100.87[2]
H_2O(110°−)	0.57		Less O	0.04	
CO_2	0.65	....			
TiO_2	0.48	1.62		100.56	
ZrO_2	0.18	....	Sp. Gr.	2.679—26° C.	
P_2O_5	0.84	0.35			

The composition of the rock is such that any calculation of the mineralogical composition must be rather arbitrary and unsatisfactory, but the following (IIa) represents roughly and

	IIa.
Orthoclase - - - -	4.8
Nephelite - - -	24.1
Biotite - - - - -	6.2
Diopside - - -	30.6
Melanite - - - - -	23.0
Schorlomite - - -	6.7
Magnetite - - - - -	3.6
Apatite - - - -	1.0
	100.0

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[1] FeS_2.

[2] Williams gives 100.57.

approximately that of Williams' specimen. It is probable that my specimen was rather richer in nephelite and poorer in dark minerals than Williams'. The composition is much the same in a general way as that of the ijolite, only that it is melanocratic, rather than mesocratic.

Jacupirangite.—A new analysis was made of the dark, coarse-grained rock, composed largely of augite, which occurs as a small mass northeast of the main area, on Cove Creek. This was deemed to be advisable since the analysis of Williams showed more CaO, or less MgO and FeO, than was necessary to form augite or any other mineral present. The analysis of Williams is given in I, and my results in II, with two other analyses for comparison.

No.	I	II	III	IV
SiO_2	36.51	38.39	38.38	45.05
Al_2O_3	8.22	7.05	6.15	6.50
Fe_2O_3	8.29	9.07	11.70	3.83
FeO	3.31	6.17	8.14	7.69
MgO	8.19	11.58	11.47	12.07
CaO	18.85	19.01	18.60	18.82
Na_2O	2.10	0.74	0.78	0.94
K_2O	1.08	0.75	0.13	0.78
H_2O 110°+	1.40	0.33	0.54	2.40
H_2O 110°−	....	0.14	0.18	
CO_2	....	0.32	none	....
TiO_2	3.11	4.54	4.32	2.65
ZrO_2	....	none	....	....
X	....	0.24	....	....
P_2O_5	....	0.82	0.17	0.15
Cl	0.03[1]	....	....	....
S	6.03	0.42	....	....
MnO	trace	0.32	0.16	....
BaO	....	trace	....	....
SrO	trace	....	....	....
	99.22	99.89	100.72	100.88

Sp. gr., 3.407—26° C.

I. Jacupirangite, Magnet Cove. J. F. Williams, analyst. *Op. cit.*, p. 227.

II. Jacupirangite, Magnet Cove. H. S. Washington, analyst.

III. Jacupirangite, Jacupiranga, Sao Paolo, Brazil. H. S. Washington, analyst.

IV. Pyroxenite, Brandberget, Gran, Norway. L. Schmelck, analyst. W. C. BRÖGGER *Q. J. G. S.*, Vol. L, p. 31, 1894.

[1] FeS_2.

While I and II are alike in a general way, yet there are marked differences in SiO_2, FeO, MgO and S. The specimen analyzed by Williams carries considerable pyrite, while mine only showed a few specks of it. The differences in the other constituents named may be attributed to alteration, especially in view of Williams' statement that the specimen analyzed by him was not fresh.[1] Analysis II calculates out readily as follows:

	IIa
Nephelite	4
Diopside	64
Augite	15
Biotite	5
Magnetite	8.7
Pyrite	0.7
Calcite	0.6
	100.0

In my former paper this pyroxenite was referred somewhat doubtfully to the jacupirangite of Derby. Through the kindness of this gentleman, to whom I would express here my deep acknowledgments, I have lately received numerous specimens of the Brazilian types. A comparison of these with the Magnet Cove specimens makes it evident that the two occurrences differ chiefly in size of grain, the Arkansas rock being very coarse, while those from Brazil are much finer grained. In all other essential respects the two are closely alike.

From the microscopical examination of the specimens which Professor Derby sent me, it is evident that the "Jacupirangites" of Brazil vary from rocks rich in nephelite, and which are true ijolites, closely analogous to those of Magnet Cove and Finland, through rocks composed predominantly of pyroxene, with small and varying amounts of magnetite and nephelite, to types extremely rich in magnetite and with no nephelite or only traces of this mineral. Accepting then the name of Jacupirangite for the medium type, the application of this name to the Magnet Cove rock is abundantly justified, since the only difference is the comparatively unimportant one of size of grain, both being holocrystalline.

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[1] WILLIAMS, *op. cit.*, p. 227.

That this identity of the two, based on mineralogical grounds, is correct, is substantiated by a chemical analysis of one of Derby's specimens made by myself. For this purpose an apparently medium specimen was chosen, composed largely of a violet-brown augite, with some magnetite (more than in the Arkansas rock) and only a little nephelite (less than in the other). No biotite was present, and only traces of apatite. This analysis, given in III of the table, is most remarkably close to that of the Magnet Cove jacupirangite in all respects, except the iron oxides. Indeed the figures for silica, magnesia, lime, soda, water, titanic acid and manganese are close enough to belong to duplicate analyses of the same specimen, and those for alumina and potash do not differ greatly. The higher iron oxides are of course connected with the more abundant magnetite, but, apart from this, the mineralogical composition is closely similar.

The closest known analogue of these rocks is probably the pyroxenite of Brandberget, an analysis of which is given in IV above. The only noteworthy differences are in SiO_2 and Fe_2O_3. That of the former apparently conditioned the formation of nephelite in the Magnet Cove and Brazil rocks and plagioclase at Brandberget, while the higher ferric oxide of II and III is to be connected partly with the more abundant magnetite in the former.

HENRY S. WASHINGTON.

[*To be continued.*]